What is claimed is:

1. A method of reducing noise in a video image, comprises the steps of:

5 (a) decomposing the video image by a transform into multiple resolution levels representing different classes of image data;

(b) selecting threshold values based on the relationships between the noise standard deviations of

10 different decomposition levels in the transform domain and the noise standard deviation of the original video image;

(c) applying a thresholding function to the transform coefficients of the classes of data in different resolution levels with different selected threshold values, to

15 essentially eliminate image information corresponding to noise in the classes of data; and

(d) reassembling the classes of data at said multiple resolution levels into a reconstructed image with reduced noise.

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2. The method of claim 1, wherein:

In step (a) decomposing the image further includes the steps of decomposing the video image by

wavelet transformation into multiple resolution levels

representing different classes of image data;

In step (b) selecting the threshold values

further includes the steps of selecting the threshold

5 values based on the relationships between the noise

standard deviations of different decomposition levels in

the wavelet domain and the noise standard deviation of the

original video image;

In step (c) applying the thresholding function

10 further includes the steps of applying the thresholding

function to the wavelet coefficients of the classes of data

in different resolution levels with different selected

threshold values, to essentially eliminate image

information corresponding to noise in the classes of data;

15 and

In step (d) reassembling the image further

includes the steps of reassembling the classes of data at

said multiple resolution levels into a reconstructed image

with reduced noise using an inverse wavelet transformation.

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3. The method of claim 2, wherein in step (b) the

threshold values are selected based on the relationships

between the noise standard deviations of different

decomposition levels in the wavelet domain and the noise

standard deviation of the original image.

4.   The method of claim 2, wherein in step (b) each

5 threshold value for each resolution level is based on the

noise standard deviation of the input image, and a linear

relationship between the noise distribution in the wavelet

domain and the noise distribution in the spatial domain.

10   5.   The method of claim 2, wherein step (c) further

includes the steps of applying a thresholding function

$\delta_T(w) = \mathrm{sgn}(w)\max(|w|-T,0)$ to different wavelet resolution

levels with a different threshold value T,   wherein each

threshold value T_i for level i is represented as:

15                    $T_i = C_i * \sigma$ with $i = 1,2,...,K$,

Wherein: k represents the number of resolution

levels;

σ represents the noise standard deviation

of the input image;

20   C_i's represent a linear relationship between

the noise distribution in the wavelet domain and the

noise distribution in the spatial domain;

sgn(w) provides the sign of a wavelet coefficient value w; and

max(a,b) provides the larger one of the two values a and b.

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6.   The method of claim 5, wherein the wavelet transform comprises a 9/7 wavelet.

7.   The method of claim 6, wherein:

10   The steps of decomposing the video image using the 9/7 wavelet transform further includes the steps of using a 9-tap low pass filter with coefficients (0.026749, -0.016864, -0.078223, 0.266864, 0.602949, 0.266864, -0.078223, -0.016864, 0.026749), and using 7-tap high pass

15 filter with coefficients (-0.045636, 0.028772, 0.295636, -0.557543, 0.295636, 0.028772, -0.045636), for decomposing the input image up to 4 levels;

The steps of applying the thresholding function further includes the steps of applying the threshold

20 function to each level i, wherein $i = 1,2,3,4$, with threshold values $T_1 = 0.50 * \sigma$, $T_2 = 0.28 * \sigma$, $T_3 = 0.13 * \sigma$, and $T_4 = 0.06 * \sigma$, such that σ is the noise standard deviation of the input image; and

The steps of reassembling the image further comprises the steps of performing an the inverse 9/7 wavelet transform to reconstruct the image.

5   8.   The method of claim 5, wherein the wavelet transform comprises a 5/3 wavelet.

9.   The method of claim 8, wherein:

The steps of decomposing the video image using

10 the 5/3 wavelet transform further includes the steps of using a 5-tap low pass filter with coefficients (-0.125, 0.250, 0.750, 0.250, -0.125), and using 3-tap high pass filter with coefficients (0.250, -0.500, 0.250), for decomposing the input image up to 4 levels;

15   The steps of applying the thresholding function further includes the steps of applying the threshold function to each level i, wherein $i = 1,2,3,4$, with threshold values $T_1 = 0.38*\sigma$, $T_2 = 0.33*\sigma$, $T_3 = 0.22*\sigma$, and $T_4 = 0.13*\sigma$, such that σ is the noise standard deviation of the input image;

20 and

The steps of reassembling the image further comprises the steps of performing an the inverse 5/3 wavelet transform to reconstruct the image.

10.   The method of claim 5, further comprising the steps of determining the C_i parameters for a discrete wavelet transform such that:

The noise standard deviations of different
5 decomposition levels in the wavelet domain decrease as the decomposition levels increase, and

The noise standard deviations in the wavelet domain are linearly dependent on the noise standard deviation of the original image.

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11.   The method of claim 10, further comprising the steps of determining the C_i parameters based on the linear dependency between the noise standard deviations in the wavelet domain and the noise standard deviation of the
15 original image, wherein the linear dependency provides a choice of the threshold values.

12.   A method of reducing noise in a video image,
20 comprises the steps of:

(a)   decomposing the video image by discrete wavelet transformation into multiple resolution levels;

(b)   selecting the threshold values based on the relationships between the noise standard deviations of

different decomposition levels in the wavelet domain and

the noise standard deviation of the original video image;

(c)   applying a thresholding function to the

wavelet coefficients of the different resolution levels

5 with different selected threshold values; and

(d)   reassembling the image by inverse discrete

wavelet transformation of the coefficients of the different

resolution levels, wherein the reassembled image has

reduced noise.

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13.   The method of claim 12, wherein in step (b) the

threshold values are selected based on the relationships

between the noise standard deviations of different

decomposition levels in the wavelet domain and the noise

15 standard deviation of the original image.

14.   The method of claim 12, wherein in step (b) each

threshold value for each resolution level is based on the

noise standard deviation of the input image, and a linear

20 relationship between the noise distribution in the wavelet

domain and the noise distribution in the spatial domain.

15.   The method of claim 12, wherein step (c) further

includes the steps of applying a thresholding function

$\delta_T(w) = \text{sgn}(w)\max(|w|-T,0)$ to different wavelet resolution

levels with a different threshold value T, wherein each

threshold value T_i for level i is represented as:

$$T_i = C_i * \sigma \quad \text{with} \quad i = 1,2,...,K,$$

5   Wherein: k represents the number of resolution

levels;

σ represents the noise standard deviation

of the input image;

C_i's represent a linear relationship between

10   the noise distribution in the wavelet domain and the

noise distribution in the spatial domain;

$\text{sgn}(w)$ provides the sign of a wavelet

coefficient value w; and

$\max(a,b)$ provides the larger one of the two

15 values a and b.

16.   The method of claim 15, wherein the wavelet

transform comprises a 9/7 discrete wavelet transform.

20   17.   The method of claim 16, wherein:

The steps of decomposing the video image using

the 9/7 wavelet transform further includes the steps of

using a 9-tap low pass filter with coefficients (0.026749,

-0.016864, -0.078223, 0.266864, 0.602949, 0.266864, -
0.078223, -0.016864, 0.026749), and using 7-tap high pass
filter with coefficients (-0.045636, 0.028772, 0.295636, -
0.557543, 0.295636, 0.028772, -0.045636), for decomposing
5 the input image up to 4 levels;

The steps of applying the thresholding function
further includes the steps of applying the threshold
function to each level i, wherein $i=1,2,3,4$, with threshold
values $T_1 = 0.50*\sigma$, $T_2 = 0.28*\sigma$, $T_3 = 0.13*\sigma$, and $T_4 = 0.06*\sigma$, such
10 that σ is the noise standard deviation of the input image;
and

The steps of reassembling the image further
comprises the steps of performing an the inverse 9/7
discrete wavelet transform to reconstruct the image.
15

18.   The method of claim 15, wherein the wavelet
transform comprises a 5/3 discrete wavelet transform.

19.   The method of claim 18, wherein:
20   The steps of decomposing the video image using
the 5/3 wavelet transform further includes the steps of
using a 5-tap low pass filter with coefficients (-0.125,
0.250, 0.750, 0.250, -0.125), and using 3-tap high pass

filter with coefficients (0.250, -0.500, 0.250), for decomposing the input image up to 4 levels;

.5 The steps of applying the thresholding function further includes the steps of applying the threshold function to each level i, wherein $i = 1,2,3,4$, with threshold values $T_1 = 0.38 * \sigma$, $T_2 = 0.33 * \sigma$, $T_3 = 0.22 * \sigma$, and $T_4 = 0.13 * \sigma$, such that σ is the noise standard deviation of the input image; and

10 The steps of reassembling the image further comprises the steps of performing an the inverse 5/3 discrete wavelet transform to reconstruct the image.

20.   The method of claim 15, further comprising the steps of determining the C_i parameters for a discrete

15 wavelet transform such that:

The noise standard deviations of different decomposition levels in the wavelet domain decrease as the decomposition levels increase, and

The noise standard deviations in the wavelet

20 domain are linearly dependent on the noise standard deviation of the original image.

21. The method of claim 20, further comprising the steps of determining the C_i parameters based on the linear dependency between the noise standard deviations in the wavelet domain and the noise standard deviation of the

5 original image, wherein the linear dependency provides a choice of the threshold values.

22. An image processing system for reducing noise in a video image, comprising:

10   (a)   transform processor that decomposes the video image into multiple resolution levels representing different classes of image data;

   (b)   a thresholding processor the applies a thresholding function to the transform coefficients of the

15 classes of data in different resolution levels with different selected threshold values, to essentially eliminate image information corresponding to noise in the classes of data,

   Wherein the threshold values are based on the

20 relationships between the noise standard deviations of different decomposition levels in the transform domain and the noise standard deviation of the original video image; and

(s) an inverse transform processor that reassembles the classes of data at said multiple resolution levels into a reconstructed image with reduced noise.

5   23. The system of claim 22, wherein:

The transform processor comprises a wavelet transform processor that decomposes the video image by wavelet transformation into multiple resolution levels representing different classes of image data;

10   The threshold values are based on the relationships between the noise standard deviations of different decomposition levels in the wavelet domain and the noise standard deviation of the original video image;

The thresholding processor applies the

15 thresholding function to the wavelet coefficients of the classes of data in different resolution levels with different selected threshold values, to essentially eliminate image information corresponding to noise in the classes of data; and

20   The inverse transform processor reassembles the classes of data at said multiple resolution levels into a reconstructed image with reduced noise using an inverse wavelet transformation.

24.   The system of claim 23, wherein the threshold
values are based on the relationships between the noise
standard deviations of different decomposition levels in
the wavelet domain and the noise standard deviation of the
5 original image.

25.   The system of claim 23, wherein each threshold
value for each resolution level is based on the noise
standard deviation of the input image, and a linear
10 relationship between the noise distribution in the wavelet
domain and the noise distribution in the spatial domain.

26.   The system of claim 23, wherein the threshold
processor further applies the thresholding function
15 $\delta_T(w) = \text{sgn}(w)\max(|w|-T,0)$ to different wavelet resolution
levels with a different threshold value T, wherein each
threshold value T_i for level i is represented as:

$$T_i = C_i * \sigma \quad \text{with} \quad i = 1,2,...,K ,$$

Wherein: k represents the number of resolution
20   levels;

        σ represents the noise standard deviation
of the input image;

C_i's represent a linear relationship between the noise distribution in the wavelet domain and the noise distribution in the spatial domain;

sgn(w) provides the sign of a wavelet

5 coefficient value w; and

max(a,b) provides the larger one of the two values a and b.

27.   The system of claim 26, wherein the transform

10 processor comprises a 9/7 wavelet transform processor.

28.   The system of claim 27, wherein:

The transform processor comprises a 9-tap low pass filter with coefficients (0.026749, -0.016864, -

15 0.078223, 0.266864, 0.602949, 0.266864, -0.078223, -0.016864, 0.026749), and a 7-tap high pass filter with coefficients (-0.045636, 0.028772, 0.295636, -0.557543, 0.295636, 0.028772, -0.045636), for decomposing the input image up to 4 levels;

20   The thresholding processor applies the threshold function to each level i, wherein $i = 1,2,3,4$, with threshold values $T_1 = 0.50 * \sigma$, $T_2 = 0.28 * \sigma$, $T_3 = 0.13 * \sigma$, and $T_4 = 0.06 * \sigma$, such

that σ is the noise standard deviation of the input image; and

The inverse transform processor comprises an inverse 9/7 wavelet transform processor.

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29. The system of claim 26, wherein the transform processor comprises a 5/3 wavelet transform processor.

30. The system of claim 29, wherein:

10 The transform processor comprises a 5-tap low pass filter with coefficients (-0.125, 0.250, 0.750, 0.250, -0.125), and a 3-tap high pass filter with coefficients (0.250, -0.500, 0.250), for decomposing the input image up to 4 levels;

15 The thresholding processor applies the threshold function to each level i, wherein $i = 1,2,3,4$, with threshold values $T_1 = 0.38*\sigma$, $T_2 = 0.33*\sigma$, $T_3 = 0.22*\sigma$, and $T_4 = 0.13*\sigma$, such that σ is the noise standard deviation of the input image; and

20 The inverse transform processor comprises an inverse 5/3 wavelet transform processor.

31. The system of claim 26, wherein the C_i parameters for a discrete wavelet transform are selected such that:

The noise standard deviations of different decomposition levels in the wavelet domain decrease as the

5 decomposition levels increase, and

The noise standard deviations in the wavelet domain are linearly dependent on the noise standard deviation of the original image.

10   32. The system of claim 31, wherein the C_i parameters are based on the linear dependency between the noise standard deviations in the wavelet domain and the noise standard deviation of the original image, wherein the linear dependency provides a choice of the threshold

15 values.